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STUDY BY THE STAFF OF THE U.S.

General Accounting Office

Use Of Computers By Firms Providing Architect-Engineer Services To Federal Agencies

COMPLETED
ORIGINAL

GAO's survey of 745 firms providing architect-engineer services to Federal agencies showed that 76 percent used computers in providing design services to clients. In addition, GAO's survey indicated that computers were used less on selected Federal projects--64 percent, and computers were used primarily to do tasks which were not practical using manual methods.

This staff study presents the results of GAO's questionnaire survey on computer use. The survey was conducted as part of GAO's review of problems experienced by architect-engineer firms using or attempting to use computer aids on Federal design projects. GAO's findings, conclusions, and recommendations resulting from the review are presented in a separate report to the Congress entitled "Agencies Should Encourage Greater Computer Use on Federal Design Projects," LCD-81-7.

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LCD-81-2

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FOREWORD

During 1979 we examined the problems experienced by firms using computer aids on Federal design projects. As part of the planning effort for this review, we made a questionnaire survey of firms providing architectural and engineering services to Federal agencies. Our objectives were to obtain sufficient data to use in planning the scope and depth of our review and to identify firms which had experienced problems relating to computer use on Federal projects.

The data provided by firms was very helpful to us in achieving our objectives, and we are grateful to those firms that took the time and effort to respond. While the data provided has fulfilled our purposes, we believe this same data may be useful, or at least of interest, to others, including the firms which responded to the survey. Therefore, we have prepared this staff study as a means of disseminating the survey results so that people, both inside and outside of Government, in policymaking, evaluating, and planning positions may have access to the statistical data.

Care should be taken in using this data. The results of the survey represent only the use being made of computers by the responding firms and should not be projected to the total number of firms working on projects for the Federal Government or to the architect-engineer community as a whole.

The survey was conducted as part of our review of problems experienced by architect-engineer firms using or attempting to use computer aids on Federal design projects. Our findings, conclusions, and recommendations resulting from the review are presented in a separate report to the Congress entitled "Agencies Should Encourage Greater Computer Use on Federal Design Projects," LCD-81-7.

This study was prepared by the Logistics and Communications Division staff. Questions regarding the contents of the study or about the survey should be directed to Ronald King, Team Leader for this assignment, at (202) 566-1314.



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D I G E S T

The General Accounting Office (GAO) has made a survey to determine the extent that architectural and engineering firms providing design services to Federal agencies use computer-aided methods in the design process. The 800 firms surveyed were not selected on a statistical sampling basis, and therefore, the survey results should not be projected over the entire architect-engineer community nor even all firms providing design services to Federal agencies. Nevertheless, the response--nearly 94 percent--was very good, and GAO believes that even the raw data will be of interest to Federal agencies, the architect-engineer community, and others.

The results of this survey provide some insight into (1) how computer methods are used in the design process, (2) how computer services are provided, (3) why computers are used, and (4) which applications are currently being used and which applications firms are planning to use.

In summary, GAO's analysis of 745 survey responses showed that:

- 76.1 percent of the responding firms used computers in some way during the design process in providing design services to their clients. (See p. 9.)
- Use of computer methods on selected Federal projects was slightly lower--64.3 percent. (See p. 16.)
- Computers were used heavily in the engineering areas, and a trend was developing toward using computers in the specifications and cost estimating areas. (See p. 10.)

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- The primary reason firms used computers was to carry out tasks which were not practical using manual methods--242 firms. (See p. 14.)
- Most firms provided computer services to their clients by using either commercial time-sharing services--266 firms--or their own computers--252 firms. (See p. 15.)
- When firms planned to use computers on a Federal project, the computer costs were often buried in either overhead or labor figures, rather than being listed as direct costs clearly identified as computer costs. (See p. 25.)

CHAPTER 1

THE SURVEY

BACKGROUND AND DEFINITIONS

We have been examining the use of computer technology in building design since 1976. Our initial effort explored the benefits of computer-aided building design, the problems and inhibitors slowing its development, and the avenues for promoting the beneficial applications of computer techniques. Our findings were presented in a staff study entitled "Computer-Aided Building Design," LCD-78-300, July 11, 1978. Our latest efforts in this area concern the problems architects and engineers are experiencing by using computer-aided techniques on Federal projects. As part of this work, we surveyed firms providing architectural and engineering services to Federal agencies (1) to gain some insight into the use of computer methods in the design process, (2) to determine how computer services were provided, (3) to learn why computers were used, and (4) to find out which computer applications firms were using as of December 1978 and which ones firms were planning to use by December 1980.

In our survey, we defined computer use as any application of computers in the design process. We excluded all accounting, fiscal, and personnel management uses. We defined design process in its broadest sense--all functions or operations from programming and architectural conception through the preparation of working drawings and construction specifications. We also included computer applications in the construction management area, although we recognized that most firms would not normally consider such uses as part of the "design process."

WHY WAS THE SURVEY MADE?

In our 1978 staff study, we commented on several factors which practicing architects and engineers and experts in the field identified as having inhibited the development and use of computer-aided building design technology in the United States. One of these factors was Federal contracting policies and procedures. In our 1978 study we found that Federal agencies, as building owners, could benefit from the use of computers by architects and engineers doing work for them. Therefore, we felt this factor should be looked into to determine whether Federal policies and procedures do, in fact, inhibit the beneficial use of computer-aided methods by architect-engineer firms working for Federal agencies. Our first step was to understand the size and complexity of the problem and its significance.

Very little information was available on which firms were using computer aids and the extent computers were being used on Federal and non-Federal work. We realized that the use of normal auditing techniques would have made collecting such data costly and time consuming; such an effort would have been infeasible. The only viable alternative appeared to be a questionnaire survey with selective interviews to identify specific problems being experienced by firms working for Federal agencies.

SCOPE OF SURVEY

How many firms should be surveyed was our first question. We felt that we needed at least 200 responses to draw any conclusions from the data. We were aware that architects and engineers, as a group, are not prone to responding to questionnaires. Assuming a 25-percent response rate, we decided to send out 800 questionnaires.

Probably the most difficult task regarding the use of the questionnaire was the development of the mailing list. We immediately recognized that we would be unable to make a statistical sample because we would not be able to develop a complete list of firms doing work for Federal agencies from which to draw a random sample. Using information available in our files and information provided by 11 Federal agencies included in our review, we developed a list of 1,000 firms which had done work for Federal agencies from 1976 to 1978. Using telephone books from the public library, various books listing architectural and engineering firms, professional society/association rosters, advertisements in trade journals, and personal contacts, we obtained addresses for 800 of these firms. Since we had exhausted our readily available sources and had obtained our goal of 800 addresses, we decided that it would be unproductive to search for more addresses.

DESIGNING THE QUESTIONNAIRE

Our main objective was to get a response that would provide us sufficient information to use for programming our review of problems experienced by firms using computers on Federal projects. Our secondary objective was to keep the questionnaire short and to the point in order to facilitate the accomplishment of our primary objective--an adequate response.

The questions were developed in close coordination among the audit staff, our technical consultants, our systems analysis staff, and our psychologist. A concerted effort

was made to insure that architects and engineers could understand our questions. Before mailing the 800 questionnaires, we tested it on 4 design firms located in Washington, D.C. These tests indicated that some minor wording changes were needed, and more importantly, that we probably could increase our response rate with a better format. With the help of our psychologist, we reformed the questionnaire before mailing it out. (See app. I.)

The results far exceeded our greatest expectations and hopes. Of the 800 questionnaires mailed, 750 firms returned them completed. One firm returned the questionnaire with a letter stating it did not have time to respond, and four questionnaires were returned undeliverable. This is nearly a 94-percent response rate.

CHAPTER 2

RESULTS OF THE SURVEY

All the questionnaire responses were keypunched and placed into a data base. We tabulated the responses and analyzed the data in a variety of ways. However, five responses were received too late to be included in the analysis. Therefore, most of the data which follows is based on responses from 745 firms.

The questionnaire had three parts. The first section asked questions about the firm's general use of computers in the design process. The second section included questions regarding the firm's use of computers on a specific Federal project. The final section pertained to Federal contracts in general.

DEMOGRAPHICS OF THE FIRMS RESPONDING TO THE QUESTIONNAIRE

We asked firms to submit a copy of page 4 from a recent Standard Form 254--Architect-Engineer and Related Services Questionnaire. Using a keypunch worksheet, we selected certain information from this form and keypunched it along with the questionnaire responses. (See app. II for a copy of the worksheet.) All firms did not submit their Standard Form 254s, so some of the demographic information was based on less than 745 firms. While a wide variety of firms responded, to facilitate analysis, we grouped firms into four categories--architect, engineer, architect-engineer, and other. Using the responses to question 1 and the selected Standard Form 254 data, we classified firms by type, size, and age. (See figs. 1 to 6.)

Figure 1

Classification Of Firms
Responding To Questionnaire

<u>Type of firm</u>	<u>Number</u>	<u>Percent</u>
Architects:		
Architect	127	17.0
Architect-planner	<u>59</u>	<u>8.0</u>
Total	<u>186</u>	<u>25.0</u>
Engineers:		
Consulting engineer	176	23.6
Engineer-planner	<u>24</u>	<u>3.2</u>
Total	<u>200</u>	<u>26.8</u>
Architect-engineers:		
Architect-engineer-planner	141	18.9
Architect-engineer	75	10.1
Engineer-architect-planner	63	8.5
Engineer-architect	<u>39</u>	<u>5.2</u>
Total	<u>318</u>	<u>42.7</u>
Others:		
Design-construct	9	1.2
Planner	4	0.5
Soil or geotechnical engineer	4	0.5
Surveyor	2	0.3
Construction management	2	0.3
Energy consultant	1	0.1
Other	<u>19</u>	<u>2.6</u>
Total	<u>41</u>	<u>5.5</u>
Total	<u>745</u>	<u>100.0</u>

Note: Five additional responses were received after the cutoff date--one architect, one architect-engineer-planner, one consulting engineer, and two engineer-architect firms.

Figure 2

Minority Firms

<u>Type of firm</u>	<u>Number</u>
Architect	9
Engineer	9
Architect-engineer	11
Other	<u>1</u>
Total	<u>30</u>

Figure 3

Size Of Firms
By Number Of Employees

<u>Number of employees</u>	<u>Type of firm</u>				<u>Total</u>
	<u>Architect</u>	<u>Engineer</u>	<u>Architect-engineer</u>	<u>Other</u>	
1-10	58	16	10	1	85
11-25	67	35	62	3	167
26-50	23	35	54	5	117
51-100	13	34	37	1	85
101-250	5	25	51	8	89
Over 250	<u>1</u>	<u>21</u>	<u>62</u>	<u>11</u>	<u>95</u>
Total	<u>167</u>	<u>166</u>	<u>276</u>	<u>29</u>	<u>638</u>
Data not provided	<u>19</u>	<u>34</u>	<u>42</u>	<u>12</u>	<u>107</u>
Total	<u>186</u>	<u>200</u>	<u>318</u>	<u>41</u>	<u>745</u>

Figure 4

Size Of Firms
By Number Of Offices

<u>Number of offices</u>	<u>Type of firm</u>				<u>Total</u>
	<u>Architect</u>	<u>Engineer</u>	<u>Architect- engineer</u>	<u>Other</u>	
1	132	80	120	11	343
2	21	23	43	1	88
3	10	20	25	1	56
4	3	9	20	5	37
5	1	7	13	3	24
6 or more	<u>1</u>	<u>28</u>	<u>58</u>	<u>8</u>	<u>95</u>
Total	<u>168</u>	<u>167</u>	<u>279</u>	<u>29</u>	<u>643</u>
Data not provided	<u>18</u>	<u>33</u>	<u>39</u>	<u>12</u>	<u>102</u>
Total	<u>186</u>	<u>200</u>	<u>318</u>	<u>41</u>	<u>745</u>

Figure 5

Size Of Firms
By Average Annual Fees
Over The Last 3 Years

<u>Fees</u>	<u>Number of firms</u>
Less than \$500,000	160
\$500,000 to \$1,499,999	181
\$1,500,000 to \$2,499,999	76
\$2,500,000 and over	<u>188</u>
Total	<u>605</u>
Data not provided	<u>140</u>
Total	<u>745</u>

Figure 6

Age Of Firms

<u>Year established</u>	<u>Type of firm</u>				<u>Total</u>
	<u>Architect</u>	<u>Engineer</u>	<u>Architect- engineer</u>	<u>Other</u>	
1827-1904	1	5	21	3	30
1905-1934	8	19	60	4	91
1935-1944	14	12	21	2	49
1945-1954	35	49	67	3	154
1955-1964	57	47	65	9	178
1965-1974	48	31	40	7	126
1975-1976	<u>4</u>	<u>2</u>	<u>4</u>	<u>1</u>	<u>11</u>
Total	<u>167</u>	<u>165</u>	<u>278</u>	<u>29</u>	<u>639</u>
Data not provided	<u>19</u>	<u>35</u>	<u>40</u>	<u>12</u>	<u>106</u>
Total	<u>186</u>	<u>200</u>	<u>318</u>	<u>41</u>	<u>745</u>

Frequencies:

1827 - 1	1899 - 1	1917 - 5	1932 - 4	1947 - 15	1962 - 15
1832 - 1	1900 - 4	1918 - 1	1933 - 1	1948 - 13	1963 - 13
1853 - 3	1901 - 1	1919 - 8	1934 - 4	1949 - 11	1964 - 8
1869 - 2	1902 - 1	1920 - 4	1935 - 3	1950 - 14	1965 - 13
1878 - 1	1903 - 1	1921 - 4	1936 - 3	1951 - 12	1966 - 16
1879 - 1	1905 - 3	1922 - 2	1937 - 5	1952 - 13	1967 - 20
1880 - 1	1906 - 2	1923 - 3	1938 - 6	1953 - 10	1968 - 15
1881 - 1	1907 - 1	1924 - 2	1939 - 3	1954 - 19	1969 - 11
1885 - 3	1908 - 3	1925 - 3	1940 - 5	1955 - 13	1970 - 10
1887 - 1	1909 - 5	1926 - 1	1941 - 5	1956 - 29	1971 - 9
1889 - 1	1910 - 4	1927 - 2	1942 - 9	1957 - 18	1972 - 13
1890 - 1	1912 - 2	1928 - 9	1943 - 2	1958 - 22	1973 - 5
1892 - 1	1913 - 1	1929 - 2	1944 - 8	1959 - 16	1974 - 14
1895 - 1	1914 - 4	1930 - 1	1945 - 20	1960 - 25	1975 - 6
1897 - 2	1915 - 6	1931 - 1	1946 - 27	1961 - 19	1976 - 5
1898 - 1	1916 - 3				

ARE COMPUTERS USED IN
THE DESIGN PROCESS?

We asked firms whether they used computers in the design process, either through their own use or through their consultants. The responses showed that 567 firms or 76 percent were using computers in the design process. (See figs. 7 and 8.)

Figure 7

Firms Using Computers
In The Design Process

<u>Type of firm</u>	<u>Total</u>	<u>Users</u>	<u>Percent</u>
Architect	186	73	39.2
Engineer	200	190	95.0
Architect-engineer	318	276	86.8
Other	<u>41</u>	<u>28</u>	68.3
Total	<u>745</u>	<u>567</u>	76.1

Figure 8

Minority Firms Using Computers
In The Design Process

<u>Type of firm</u>	<u>Total</u>	<u>Users</u>	<u>Percent</u>
Architect	9	4	44.4
Engineer	9	7	77.8
Architect-engineer	11	9	81.8
Other	<u>1</u>	<u>-</u>	0.0
Total	<u>30</u>	<u>20</u>	66.7

IN WHICH AREAS DO FIRMS
USE COMPUTERS?

We asked firms what applications they were using in December 1978 and those they were planning to use over the next 24 months (by December 1980). The responses showed that computers were being used heavily in the engineering areas and that a trend was developing toward using computers in the specifications and cost estimating areas. (See figs. 9 to 11.)

Figure 9
Areas Where Firms Are Using
And Where They Plan To Use
Computers In The Design Process

<u>Application</u>	<u>Number of firms</u>	
	<u>Using</u> <u>as of</u> <u>12/78</u>	<u>Additional</u> <u>planned use by</u> <u>12/80</u>
Structural engineering	322	30
Civil engineering	281	24
Mechanical engineering	276	33
Energy analysis	222	55
Electrical engineering	180	50
Life-cycle costing	166	61
Specifications	140	100
Cost estimating	137	71
Lighting analysis	130	48
Construction management	119	29
Functional programming	76	38
Soil analysis	69	7
Drafting	64	47
Perspective drawing	29	24
Other areas	79	2

Figure 10
Areas Where Firms Use Or
Plan To Use Computer Applications
By Type Of Firm

Area	Firm uses	Plan to use before 12/80	Consultants use	Firm marked both	
	(1)	(2)	(3)	(1) & (2)	(2) & (3)
Architects:					
Civil engineering	1	1	72	1	-
Structural engineering	5	-	132	1	1
Mechanical engineering	2	1	137	-	-
Electrical engineering	2	1	75	-	1
Soil analysis	1	1	13	-	-
Energy analysis	2	5	98	1	4
Lighting analysis	2	1	53	-	-
Cost estimating	9	12	26	5	2
Life-cycle costing	6	9	64	3	5
Functional programming	9	13	1	-	2
Specifications	18	12	21	3	5
Perspective drawing	4	3	3	-	-
Drafting	1	4	4	-	-
Construction management	3	6	7	-	-
Other	8	-	5	1	-
Engineers:					
Civil engineering	97	6	9	7	-
Structural engineering	83	8	21	8	2
Mechanical engineering	81	12	18	6	-
Electrical engineering	45	19	22	3	-
Soil analysis	18	2	18	1	1
Energy analysis	60	17	10	2	-
Lighting analysis	32	18	13	2	-
Cost estimating	28	19	2	2	-
Life-cycle costing	47	16	10	-	-
Functional programming	15	8	-	1	-
Specifications	29	35	2	2	-
Perspective drawing	4	8	1	-	-
Drafting	20	11	1	1	-
Construction management	24	7	3	-	-
Other	24	-	3	1	-

Figure 10 (contd.)

Areas Where Firms Use Or
Plan To Use Computer Applications
By Type Of Firm

<u>Area</u>	<u>Firm</u> <u>uses</u> <u>(1)</u>	<u>Plan to use</u> <u>before 12/80</u> <u>(2)</u>	<u>Consultants</u> <u>use</u> <u>(3)</u>	<u>Firm marked both</u>	
				<u>(1) & (2)</u>	<u>(2) & (3)</u>
Architect-engineers:					
Civil engineering	158	13	31	6	4
Structural engineering	199	15	48	14	4
Mechanical engineering	163	18	61	13	2
Electrical engineering	115	26	42	7	2
Soil analysis	34	3	37	5	-
Energy analysis	137	21	60	12	6
Lighting analysis	82	25	41	6	3
Cost estimating	74	32	26	7	4
Life-cycle costing	94	26	30	9	4
Functional programming	42	14	2	2	-
Specifications	72	44	7	10	2
Perspective drawings	18	9	2	-	1
Drafting	31	28	2	1	1
Construction management	77	14	9	2	-
Other	32	1	6	1	1
Others:					
Civil engineering	10	-	2	1	-
Structural engineering	11	-	3	1	-
Mechanical engineering	10	-	3	1	-
Electrical engineering	7	1	3	1	-
Soil analysis	10	-	1	-	-
Energy analysis	7	2	3	1	-
Lighting analysis	5	1	1	1	-
Cost estimating	11	2	1	1	-
Life-cycle costing	6	1	2	1	-
Functional programming	6	1	-	1	-
Specifications	6	2	-	-	-
Perspective drawing	3	3	-	-	-
Drafting	10	3	1	-	-
Construction management	12	2	1	1	-
Other	11	-	-	1	-

Figure 11

Number Of Computer Applications
Used By Individual Firms

<u>Number of</u> <u>applications marked</u>	<u>Number of firms</u>		
	<u>Firm</u> <u>uses</u>	<u>Plan</u> <u>to use</u>	<u>Consultants</u> <u>use</u>
0	270	504	357
1	76	92	101
2	70	74	69
3	81	29	57
4	51	20	55
5	48	15	45
6	40	6	30
7	25	1	20
8	24	2	6
9	20	1	4
10	16	-	1
11	12	-	-
12	8	1	-
13	2	-	-
14	1	-	-
15	1	-	-

WHY DO FIRMS USE COMPUTERS?

We asked firms to indicate the primary reason they use computers in the design process. Two hundred and forty-two firms responded that the primary reason is to carry out tasks which are not practical using manual methods. One hundred and fifteen firms responded that to improve the quality of designs produced was their primary reason. (See fig. 12.)

Figure 12

Primary Reasons Computers
Are Used In The Design Process

<u>Reasons</u>	<u>Type of firm</u>				<u>Total</u>
	<u>Arch.</u>	<u>Engr.</u>	<u>Arch.- enr.</u>	<u>Other</u>	
To carry out tasks which would not be practical using manual techniques	21	95	111	15	242
To improve the quality of designs produced	12	34	66	3	115
To reduce design costs	7	25	37	4	73
To speed up the design process	10	22	37	3	72
To reduce the number of design errors	1	1	8	-	10
To standardize methods	3	2	1	-	6
To comply with building codes and/or project specifications and requirements	-	2	2	-	4
Other	5	6	5	2	18

Note: Of the 567 firms using computers, 540 firms responded to this question.

HOW ARE COMPUTER SERVICES PROVIDED?

Firms generally provided computer services by using either commercial time-sharing services (266 firms) or their own computers (252 firms). Other methods used were commercial service bureaus (170 firms), leased computers (68 firms), through consultants (117 firms), and other methods (26 firms). (See figs. 13 and 14.)

Figure 13

How Computer
Services Are Provided

<u>Method used</u>	<u>Arch.</u>	<u>Engr.</u>	<u>Arch.- enr.</u>	<u>Other</u>	<u>Total</u>
Firm owns a computer	9	90	137	16	252
Firm leases a computer	5	16	43	4	68
Firm uses commercial time-sharing service	18	93	141	14	266
Firm uses a commercial service bureau	16	62	85	7	170
Consultants provide computer services	30	23	61	3	117
Other	6	9	8	3	26

Note: This was a multiple response or "check all that apply" question.

Figure 14

How Computer Services Are
Provided By Minority Firms

<u>Method used</u>	<u>Type of firm</u>				<u>Total</u>
	<u>Arch.</u>	<u>Engr.</u>	<u>Arch.- enr.</u>	<u>Other</u>	
Firm owns a computer	1	4	3	-	8
Firm leases a computer	-	1	-	-	1
Firm uses commercial time-sharing service	1	2	5	-	8
Firm uses a commercial service bureau	1	1	2	-	4
Consultants provide computer services	2	1	2	-	5

Note: This was a multiple response or "check all that apply" question.

HOW OFTEN ARE COMPUTERS
USED ON FEDERAL PROJECTS?

Firms indicated that they used computers in some way on 64 percent of the 745 Federal projects, of various types, surveyed. Data is presented in summary form and is broken down by type of project and firm. (See figs. 15 to 17.)

Figure 15

Use Of Computers On Federal Projects

Type of firm awarded contract	Total no. of projects	Firm used computer	Consultant used computer	Projects using computers	Percentage of projects computer used	Projects' computers not used
Architect	186	16	110	126	67.7	60
Engineer	200	102	37	117	58.5	83
Architect-engineer	318	165	98	215	67.6	103
Other	41	19	4	21	51.2	20
Total	745	302	257	479	64.3	266

Note: On some projects, both the firms and the consultant(s) used computers.

Figure 16

Use of Computers On Federal Projects - By Type of Project

Type of project	Total no. of projects	Firm used computer	Consultant used computer	Projects using computers	Percentage of projects computer used	Projects' computers not used
Office/general purpose building	128	47	65	95	74.2	33
Facility renovation	92	24	18	39	42.2	53
Special studies/services	75	30	16	38	50.7	37
Storage/maintenance facility	69	29	21	41	59.4	28
Hospital/medical facility	63	24	11	44	69.8	19
Laboratory/education facility	55	14	27	38	69.1	17
Pollution control	43	22	7	24	55.8	19
Housing	36	11	17	27	75.0	9
Civil engineering	35	18	12	25	71.4	10
Utilities	29	18	4	19	65.5	10
Energy conservation	27	11	8	15	55.6	12
Production plants	24	16	5	18	75.0	6
Miscellaneous small buildings	21	9	13	20	95.2	1
Water	18	15	4	16	88.9	2
Security	7	4	2	6	85.7	1
Aerospace/air defense	5	4	3	5	100.0	-
Detention centers	3	2	2	2	66.7	1
Other	10	4	1	5	50.0	5

Note: On some projects, both the firm and its consultant(s) used computers.

Figure 17

Breakdown Of Federal Projects Done By
Firms Responding To Questionnaire

Type of project	Number of projects	Type of firm			
		Architect	Engineer	Architect- engineer	Other
Office/general purpose building	128	51	11	62	4
Facility renovation	92	29	22	41	-
Special studies/ services	75	13	27	21	14
Storage/maintenance facility	69	12	20	35	2
Hospital/medical facility	63	18	10	32	3
Laboratory/education facility	55	23	2	27	3
Pollution control	43	1	26	13	3
Housing	36	19	3	14	-
Civil engineering	35	1	24	10	-
Utilities	29	1	15	9	4
Energy conservation	27	3	11	12	1
Production plants	24	-	7	14	3
Misc. small build- ings	21	8	4	7	2
Water	18	-	10	7	1
Security	7	1	2	4	-
Aerospace	5	-	2	2	1
Detention centers	3	2	-	1	-
Other	<u>10</u>	<u>1</u>	<u>3</u>	<u>6</u>	<u>-</u>
Total	<u>740</u>	<u>183</u>	<u>199</u>	<u>317</u>	<u>41</u>

Note: Data was not provided on five projects.

IN WHICH AREAS AND HOW FREQUENTLY
WERE COMPUTER APPLICATIONS USED
ON FEDERAL PROJECTS?

Survey responses showed that the computer applications most often used on the Federal projects surveyed were structural engineering (251 projects), mechanical engineering (235 projects), and energy analysis (183 projects). The applications used the least were functional programming (11 projects), perspective drawing (5 projects), drafting (18 projects), and construction management (16 projects). (See fig. 18.)

WHY WERE COMPUTERS NOT USED?

On those projects where computers were not used, we asked the firm to indicate the reason. Computers were not used on 266 projects. The most frequently cited reasons for nonuse were work did not involve aspects where computers were normally used (88 projects) and work was not sufficiently extensive or complex to require computers (97 projects). (See figs. 19 and 20.)

Figure 18
Types of Computer Applications Used on Federal Projects
By Project Type

Applications and number of projects on which each was used																
Project type	Total no. of projects	Civil engineering	Structural engineering	Mechanical engineering	Electrical engineering	Soil analysis	Energy analysis	Lighting analysis	Specifications	Cost estimating	Life-cycle costing	Functional programming	Drafting	Perspective drawing	Construction management	Other applications
Office/general purpose building	128	18	61	63	27	3	54	20	15	14	30	2	2	2	4	4
Hospital/medical facility	63	9	33	30	16	1	24	15	6	8	15	1	2	1	3	3
Laboratory/education facility	55	4	23	31	10	1	20	7	5	9	12	2	1	1	1	3
Production plant	24	5	14	9	4	2	6	5	2	4	4	-	-	1	1	2
Storage/maintenance facility	69	9	23	17	11	1	13	6	5	6	8	-	-	1	-	2
Utilities	29	4	8	9	6	-	4	-	3	-	3	1	-	1	1	1
Water	18	13	6	1	1	2	-	-	1	3	1	2	-	1	-	3
Facility renovation	92	5	15	21	8	1	16	3	4	7	8	-	-	-	1	2
Energy conservation	27	-	-	8	2	-	15	1	2	3	8	-	-	-	-	1
Pollution control	43	13	7	8	3	1	1	-	3	4	-	-	-	-	-	7
Special studies/services	75	14	8	6	5	4	5	3	2	2	2	1	-	7	-	19
Housing	36	9	20	15	5	1	16	5	1	3	9	1	-	1	2	1
Civil engineering	35	14	18	2	2	11	-	1	2	-	-	1	-	2	-	9
Miscellaneous small buildings	21	7	5	9	3	2	6	1	2	1	4	-	-	-	2	2
Detention centers	3	1	2	2	2	-	1	-	-	-	1	-	-	-	-	1
Security	7	2	2	1	1	-	-	4	-	-	-	-	-	-	-	-
Aerospace/air defense	5	1	3	1	1	1	-	1	2	2	-	-	-	-	1	1
Other	10	2	3	2	1	1	2	1	-	1	-	-	-	-	-	-
Total	740	130	251	235	108	32	183	73	55	67	105	11	5	18	16	61

Note: Five firms did not respond to this question (#11).

~~Figure 10.1~~
Reasons Why Computers Were Not
Used On Federal Projects

<u>Reason</u>	<u>Total number of projects</u>	<u>Type of firm</u>			
		<u>Architect</u>	<u>Engineering</u>	<u>Architect- engineer</u>	<u>Other</u>
Firm does not ordinarily use computers	52	20	6	17	9
Work did not involve aspects where a computer was normally used	68	17	35	30	6
Work was not suffi- ciently extensive or complex to require a computer	97	18	32	43	4
Use of computer would have created diffi- culty in recover- ing costs under the contract	4	1	2	1	-
Other	16	2	6	8	-
No reason given	<u>9</u>	<u>2</u>	<u>2</u>	<u>4</u>	<u>1</u>
Number of projects on which compu- ters were not used	<u>266</u>	<u>60</u>	<u>83</u>	<u>103</u>	<u>20</u>

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Figure 20
Reasons Why Computers Were Not Used
On Federal Projects - By Type Of Project

Reasons computers not used	Type of project																	
	Office/general purpose building	Hospital/medical facility	Laboratory/education facility	Production plant	Storage/maintenance facility	Utilities	Water project	Facility renovation	Energy conservation	Pollution control	Special studies/services	Housing	Civil engineering	Miscellaneous small buildings	Detention centers	Security	Other	Total
Firm does not ordinarily use computers	11	4	11	-	-	2	-	12	1	1	7	-	-	1	1	-	-	51
Work did not involve aspects where computer is normally used	8	6	2	2	11	2	1	13	2	9	19	4	6	-	-	-	2	87
Work not sufficiently extensive or complex to require computer	11	5	4	1	17	6	1	20	7	8	7	5	2	-	-	1	2	97
Use of computer would have created difficulty in recovering costs under the contract	-	-	-	2	-	-	-	1	-	-	1	-	-	-	-	-	-	4
Other	1	2	-	1	-	-	-	6	2	-	2	-	1	-	-	-	1	16

HOW WERE COMPUTER COSTS
LISTED IN FEE PROPOSALS?

On those projects where computers were used, we asked the firms to indicate how they listed their computer costs in the fee proposal. The responses showed that firms frequently buried the computer costs in either their overhead or labor figures. Only 172 of 474 firms listed their computer costs as direct costs. An additional 24 firms had these costs listed as directed costs, but identified the costs by some label other than computer services. (See fig. 21.)

Figure 21

Listing Of Computer Costs
In Fee Proposals

<u>Method used</u>	<u>Total number of firms</u>	<u>Type of firm</u>			
		<u>Architect</u>	<u>Engineer</u>	<u>Architect- engineer</u>	<u>Other</u>
Listed as a direct cost and identified as computer services cost	172	4 ²	45	75	9
Listed as a direct cost but identified in another way; e.g. energy analysis	24	8	9	7	-
Buried in labor figures	94	24	18	50	2
Buried in overhead costs	219	62	50	98	9
Other	37	7	11	18	1

Note: This was a check all that apply question. More than one method is often used in fee proposals.

WERE AGENCIES SATISFIED
WITH COMPUTER COSTS?

We asked the firms whether Federal agencies were dissatisfied with the computer costs included in their fee proposals for their projects. Thirty firms indicated that the Federal agency negotiators had questioned the computer costs listed. (See fig. 22.) These costs were listed as a direct cost on 25 of these projects. (See fig. 23.) In most cases, agency officials felt that the costs were too high. (See fig. 24.) Another thirty firms indicated in their narrative comments on question 19 that they had had problems regarding computer costs on Federal projects, although not on the particular project we had selected. Also, many firms said that the reasons they had no problems on computer costs was that the costs were buried and the agency negotiators never discussed the use of computers or the associated costs.

Figure 22

Agency Dissatisfaction With
Architect-engineer Computer Cost Estimates
By Type Of Firm

<u>Type of firm</u>	<u>Number</u>
Architect	6
Engineer	8
Architect-engineer	15
Other	<u>1</u>
Total	<u>30</u>

Figure 23

Agency Dissatisfaction With
Architect-engineer Computer Cost Estimates

<u>Type of project</u>	<u>Number of projects</u>	<u>Reasons for dissatisfaction</u>		
		<u>Cost too high</u>	<u>Improper cost category</u>	<u>Other</u>
Hospital/medical facility	7	6	1	1
Office/general purpose building	5	3	-	2
Laboratory/education facility	4	3	-	2
Miscellaneous small buildings	3	3	-	-
Energy conservation	2	2	-	-
Housing	2	2	-	-
Civil engineering	2	1	-	1
Production plant	1	1	-	-
Storage/maintenance facility	1	1	-	-
Utilities	1	1	-	1
Water	1	-	-	1
Special studies/services	1	1	-	-
Total	<u>30</u>	<u>24</u>	<u>1</u>	<u>8</u>

Note: Some firms cited two reasons for agency dissatisfaction.

Figure 24

Classification Of Computer Costs
On The 30 Projects Where Federal Negotiators Were
Dissatisfied With Computer Costs

<u>Classification</u>	<u>Architect</u>	<u>Engineer</u>	<u>Architect- engineer</u>	<u>Other</u>	<u>Total</u>
Identified as direct computer costs	6	7	11	1	25
Buried in labor costs	1	1	4	-	6
Buried in overhead	1	1	3	-	5
Buried in another item	1	-	1	-	2

Note: Computer costs were included in more than one classification on some projects.

COMPARISON OF COMPUTER USE
WITH NUMBER OF BRANCH OFFICES OPERATED
BY THE FIRM AND WITH THE FIRM'S AGE

We compared the firms' use of computers considering the number of branch offices each firm had and the number of years each firm had been in existence. We found that computer use increased as the number of branches increased. (See fig. 25.) Regarding the firms' age, we found that the firms which had been in existence the longest were more likely to use computers than those firms which had not existed long. (See fig. 26.)

Figure 25

Comparison Of Computer Use
With Number Of Branch Offices Operated By Firm

Number of offices	Type of firm														
	Architect			Engineer			Architect-engineer			Other			Total		
	Do not use	Use	Percent using	Do not use	Use	Percent using	Do not use	Use	Percent using	Do not use	Use	Percent using	Do not use	Use	Percent Using
1	82	50	37.9	7	73	91.3	32	88	73.3	5	6	54.4	126	217	63.3
2	12	8	40.0	1	22	95.7	3	40	93.0	-	1	100.0	16	71	81.6
3	4	6	60.0	-	20	100.0	2	23	92.0	-	1	100.0	6	50	89.3
4	2	1	33.3	-	9	100.0	-	20	100.0	1	4	80.0	3	34	91.9
5	-	1	100.0	-	7	100.0	1	12	92.3	-	3	100.0	1	23	95.8
6	-	1	100.0	-	28	100.0	1	57	98.3	1	7	87.5	2	93	97.9
Total	<u>100</u>	<u>67</u>	40.1	<u>8</u>	<u>159</u>	95.2	<u>39</u>	<u>240</u>	86.0	<u>7</u>	<u>22</u>	75.9	<u>154</u>	<u>488</u>	76.0

Figure 26

Comparison Of Computer Use
With Age Of Firm

Year firm was established	Type of firm														
	Architect			Engineer			Architect-engineer			Other			Total		
	Do not use	Use	Percent using	Do not use	Use	Percent using	Do not use	Use	Percent using	Do not use	Use	Percent Using	Do not use	Use	Percent using
1827 - 1904	-	1	100.0	-	5	100.0	1	20	95.2	-	3	100.0	1	29	96.7
1905 - 1934	4	3	42.9	-	19	100.0	9	51	85.0	1	3	75.0	14	76	84.4
1935 - 1944	8	6	42.9	-	12	100.0	3	18	85.7	-	2	100.0	11	38	77.6
1945 - 1954	20	15	42.9	4	45	91.8	10	57	85.1	-	3	100.0	34	120	77.9
1955 - 1964	33	24	42.1	1	46	97.9	8	57	87.7	2	7	77.8	44	134	75.3
1965 - 1974	32	16	33.3	3	28	90.3	8	32	80.0	3	4	57.1	46	80	63.5
1975 - 1976	3	1	25.0	-	2	100.0	-	4	100.0	1	-	0.0	4	7	63.6
Total	<u>100</u>	<u>66</u>	39.8	<u>8</u>	<u>157</u>	95.2	<u>39</u>	<u>239</u>	86.0	<u>7</u>	<u>22</u>	75.9	<u>154</u>	<u>484</u>	75.9

Note: Information concerning the year in which four firms were established was not available.
All four firms used computers.



**SURVEY OF FIRMS PROVIDING ARCHITECTURAL AND
ENGINEERING SERVICES TO FEDERAL AGENCIES**

Contract Number: _____

Federal Department or Agency _____

This questionnaire is designed to obtain information on the use of computer techniques by architectural and engineering firms doing work for Federal agencies. It will be used in determining whether Federal contracting procedures and practices encourage or inhibit the use of innovative computer techniques on Federal design and construction projects. It is not an audit of the project identified above, nor is it related to any audit. We have preselected a variety of Federal projects to ensure that our report accurately reflects all aspects of the computer assisted design process.

For this reason, a staff member familiar with the specific contract indicated above as well as the extent to which computer techniques are used by your firm and your consultants should complete the questionnaire.

Please complete the questionnaire and return it in the enclosed envelope within ten days of its receipt. If you require additional time or have any questions, please call Mr. Ronald King, the project manager at (202) 566-1314.

"DESIGN PROCESS"

"We are using this term" in its broadest sense defining it as ALL FUNCTIONS or operations from PROGRAMMING and ARCHITECTURAL CONCEPTION through the preparation of WORKING DRAWINGS and CONSTRUCTION SPECIFICATIONS. For the purposes of this questionnaire, we are also including COMPUTER APPLICATIONS IN THE CONSTRUCTION MANAGEMENT AREA, although most firms would not normally consider them part of the design process.

NAME _____

PHONE NUMBER _____

PLEASE READ THE ENTIRE QUESTIONNAIRE BEFORE ANSWERING THE QUESTIONS

Note: Numbers in () to the right of each item are for keypunching.

Numbers in the response space to the left: (i.e. (1) yes (2) no) are to facilitate analysis.

APPENDIX I

APPENDIX I

(1-3)

I. GENERAL INFORMATION

1. Which of the following classifications best describes your firm?
(CHECK ONLY ONE.)

- (01) Architect (4-5)
- (02) Consulting Engineer (6-7)
- (03) Planner (8-9)
- (04) Architect-Engineer (10-11)
- (05) Architect-Engineer-Planner (12-13)
- (06) Architect-Planner (14-15)
- (07) Engineer-Architect (16-17)
- (08) Engineer-Architect-Planner (18-19)
- (09) Engineer-Planner (20-21)
- (10) Design-Construct (22-23)
- (11) Construction Management (24-25)
- (12) Surveyor (26-27)
- (13) Soil or Geotechnical Engineer (28-29)
- (14) Energy Consultant (30-31)
- (15) Other (please specify) _____ (32-33)

2. Does your firm use computers in any way in its operations? **EXCLUDE CONSULTANT USE.**

- (1) Yes (34)
- (2) No

3. Does your firm currently use, or plan to use, computers in any aspect of the design process? **EXCLUDE ACCOUNTING AND FINANCIAL AND PERSONNEL MANAGEMENT USES.**

- (1) Yes (35)
- (2) No (If no, please skip to question 6.)

4. If YES, how will the computer services be provided?
(CHECK ALL THAT APPLY.)

- (1) Firm owns a computer system(s) (36)
- (2) Firm leases a computer system(s) (37)
- (3) Firm uses a commercial time-sharing service (real-time, on line access etc.) (38)
- (4) Firm uses a commercial service bureau (usually only batch processing) (39)
- (5) Consultant(s) supplies computer services or facilities (40)
- (6) Other (please specify)

_____ (41)

5. What is the primary reason why your firm employs computer techniques in the design process?
(CHECK ONLY ONE.)

- (1) To reduce costs (42)
- (2) To carry out tasks which would not be practical using manual techniques (43)
- (3) To improve the quality of designs produced (44)
- (4) To reduce the number of design errors (45)
- (5) To speed up the design process (46)
- (6) To standardize methods (47)
- (7) In order to comply with building codes and/or project specifications and requirements (48)
- (8) Other (please specify)

_____ (49)

APPENDIX I

APPENDIX I

6. In which aspects of the design process does your firm currently use, or plan to use, computers, and (2) in which are they used by your consultants? (Please check all that apply.)

	Firm Uses	Firm does not now use but plan use (Next 24 months)	Consultants Use	
Civil engineering	(1)	(2)	(3)	(50)
Structural engineering	(1)	(2)	(3)	(51)
Mechanical engineering	(1)	(2)	(3)	(52)
Electrical engineering	(1)	(2)	(3)	(53)
Soil analysis	(1)	(2)	(3)	(54)
Energy analysis	(1)	(2)	(3)	(55)
Lighting analysis	(1)	(2)	(3)	(56)
Cost estimating	(1)	(2)	(3)	(57)
Life-cycle costing	(1)	(2)	(3)	(58)
Functional programming	(1)	(2)	(3)	(59)
Specifications	(1)	(2)	(3)	(60)
Perspective drawing	(1)	(2)	(3)	(61)
Drafting	(1)	(2)	(3)	(62)
Construction management	(1)	(2)	(3)	(63)
Other (please specify)	(1)	(2)	(3)	(64)

7. When your firm uses computer techniques in the design process, what percent of your firm's operating costs are computer costs. Please express your answer in terms of a range, that is enter both highest percentage of operating costs that computer costs have been and the lowest.

design-process computer costs as a
percent of operating costs

High _____ %
(65-67)

Low _____ %
(68-70)

II. EXPERIENCE UNDER THE SPECIFIC FEDERAL CONTRACT IDENTIFIED ON PAGE 1

The questions in this section concern your firm's experience using computer techniques in providing services under the specific Federal contract identified on page 1. It has been selected in order to provide us with a frame of reference. Please answer the questions which follow in terms of that contract.

Dup. (1-3)

8. Which of the following best describes the contract referred to on page 1? (CHECK ONLY ONE.)

- (1) Office or general purpose building (4-5)
- (2) hospital or medical facility
- (3) laboratory/educational facility
- (4) production plant
- (5) storage/maintenance facility
- (6) power plant
- (7) water project
- (8) facility renovation
- (9) energy conservation
- (10) pollution control
- (11) special studies
- (12) Other (please specify)

9. Was a computer used either by your firm, or by a consultant, in any design process application under the contract referred to on page 1? (PLEASE CHECK ALL THAT APPLY.)

- (1) Yes, by our firm (5)
- (2) Yes, by a consulting firm (7)
- (3) No (8)

IF YOU CHECKED "NO", PLEASE ANSWER QUESTION 10 AND SKIP TO SECTION III.

IF YOU CHECKED "YES", PLEASE SKIP TO QUESTION 11.

10. IF NO, which of the following best describes the reason why a computer was not used on the project? PLEASE CHECK ONLY ONE.

- (1) Our firm does not ordinarily use computers. (9)
- (2) The work on the project did not involve aspects on which we, or our consultants, normally use computer applications.
- (3) Work on the project was not sufficiently extensive or complex to require computer use.
- (4) Use of computer techniques would have created difficulty in recovering costs under the contract.
- (5) Other (Please specify) _____

APPENDIX I

11. In which aspects of the design process was a computer used by your firm, or your consultants, on the contract referred to on page 1? (PLEASE CHECK ALL THAT APPLY.)

- (01) Civil (10-11)
engineering
 - (02) Structural (12-13)
engineering
 - (03) Mechanical (14-15)
engineering
 - (04) Electrical (16-17)
engineering
 - (05) Soil (18-19)
analysis
 - (06) Energy (20-21)
analysis
 - (07) Lighting (22-23)
analysis
 - (08) Specifications (24-25)
 - (09) Cost (26-27)
estimating
 - (10) Life-cycle (28-29)
costing
 - (11) Functional (30-31)
programming
 - (12) Perspective (32-33)
drawing
 - (13) Drafting (34-35)
 - (14) Construction (36-37)
management
 - (15) Other (Please
specify) (38-39)
-
-

APPENDIX I

12. In the fee proposal submitted by your firm for the award of the contract referred to on page 1, how did your firm list the cost of computer analysis? (PLEASE CHECK ALL THAT APPLY.)

- (1) Listed it as a separate line item, identified as computer cost. (40)
 - (2) Listed it as a separate line item, identified in another way. (41)
 - (3) Included it in hourly labor rate (42)
 - (4) Treated it as an element of overhead (43)
 - (5) Other (Please specify) (44)
-
-

13. During contract negotiations did the Federal agency negotiators express dissatisfaction concerning the computer cost estimates contained in your firm's proposal? (45)

- (1) Yes
- (2) No (If NO, skip to question 14)

14. IF YES, which of the following kinds of dissatisfaction were expressed by the Federal agency negotiators? (PLEASE CHECK ALL THAT APPLY.)

- (1) Proposed computer (46)
cost was too high
 - (2) Computer cost was (47)
in improper category
(e.g. overhead,
separate line item,
etc.)
 - (3) Other (Please specify) (48)
-
-

15. Approximately what percentage of your operating costs on the contract referred to above apply to computer services provided under the contract?

(49-51) 2

III. FEDERAL CONTRACTS IN GENERAL

Your answers in Section II related to a specific contract. Many of the firms receiving the questionnaire will have done work for more than one agency over the last three years and may have been awarded more than one contract by the same agency. We realize that the contract we selected may not be representative of your overall experience with Federal agencies regarding the use of computers on design and construction contracts. Therefore, the following questions concern your firm's experience on other Federal contracts it has been awarded.

16. Was the contract we selected in Section II representative of your firm's use of computers on Federal work and its experience with Federal agency contracting officers regarding computer usage and costs?

- (1) Yes (If yes, skip to question 18.) (52)
(2) No

17. IF ANSWER TO QUESTION 16 WAS NO, please describe briefly how your experiences differ from the selected contract. (Please give agency and contract or type of work to provide us with a frame of reference.)

18. Please enclose a copy of page 4 of a recently prepared Standard Form 254 with this questionnaire. It is not necessary to complete a new Standard Form 254. Any Form 254 for which information is still relatively accurate will suffice.

19. If you have any comments concerning the questionnaire, the use of computers in the design process, or other related design and construction areas, please use the space below. Thank you for your cooperation.

APPENDIX II

Survey of firms providing architectural/engineering services on Federal buildings.

from p. 4 of Form 254

Questionnaire No. (1-3)

Company name _____

A. $\frac{19}{(4-7)}$ Year Established? (Item 2)

B. Number of offices?
(8-9) 7 to complete this item - count number of offices/
 branches listed in item 7 on p. 4.

C. $\frac{\quad}{(10-13)}$ Total Personnel (item 7a)

D. Form 254 submitted by? (item 1a)
☒ 1 Parent company
☐ 2 Branch office
☐ 3 Not available
 (14)

E. Minority owned? (item 4a)
☒ 1 Yes
☐ 2 No
☐ 3 Not available
 (15)

F. Summary of Professional Services Fees
(to be copied directly from item 9)

Index to Professional Services Fees

1. Less than \$100,000
2. \$100,000 to \$250,000
3. \$250,000 to \$500,000
4. \$500,000 to \$1 million
5. \$1 million to \$2 million
6. \$2 million to \$5 million
7. \$5 million to \$10 million
8. \$10 million or more

	19 (16-19)	19 (23-26)	19 (30-33)	19 (37-40)	19 (44-47)
Federal (including overseas)	(20)	(27)	(34)	(41)	(48)
Other domestic	(21)	(28)	(35)	(42)	(49)
Other foreign	(22)	(29)	(36)	(43)	(50)

(945144)

3 (80)